TOPIC 07 – EQUILIBRIUM
7.1: DYNAMIC EQUILIBRIUM

IB Chemistry

T07D01

7.1 Dynamic equilibrium - 1 hour

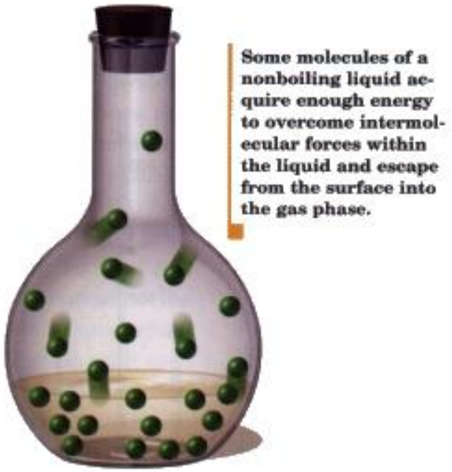
- 7.1.1 Outline the characteristics of chemical and physical systems in a state of equilibrium. (2)
- Many reactions (such as fireworks) very obviously go to (or near) completion
- In many other cases, a reverse reaction runs in competition with the forward reaction
- Many metabolic processes in the body (like the binding of oxygen to hemoglobin), and industrial processes like the production of ammonia and sulfuric acid each occur under a delicate balance between forward and reverse reactions

7.1 – Physical Equilibria

- Water evaporating from a puddle
- Propanone disappears from the palm of your hand (you can see it) through an endothermic process
- Each are examples of **open systems** where once evaporated the molecules mix with the air
- The evaporation continues as molecules gain enough kinetic energy from the surroundings to escape the surface of the liquid.
- When you place water in a sealed container a different situation arises known as a **closed system.**

7.1 – Physical Equlibria

- In the case of a closed system of water, it will still vaporize but only until the container becomes saturated with water vapor.
- At this point **equilibrium** is established
  - Some molecules still gain enough KE to escape the liquid phase into the gaseous
  - At the same time, some gaseous particles condense back into the liquid phase
  - $H_2O(l) \rightleftharpoons H_2O(g)$



7.1 – Physical Equilibria for Br_2

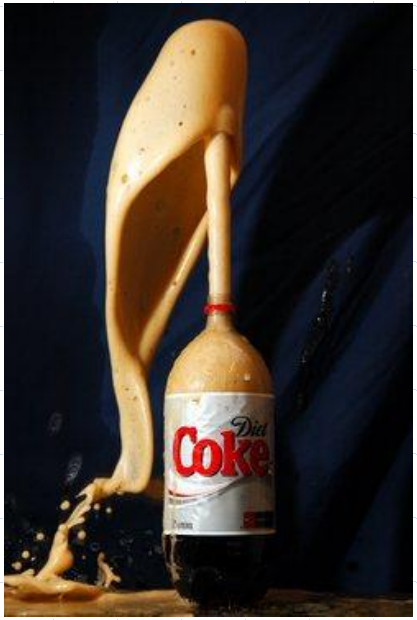
- Br is a non-metal that is liquid at room temperature but is volatile with a B.P. of 337K
- When in a sealed-container, the orange-brown vapor collects over the deep-red liquid.
- Over time the color of the vapor becomes more intense until equilibrium is reached
- $Br_2(l) \rightleftharpoons Br_2(g)$
  - Evaporation = Condensation

7.1 – Static vs Dynamic Equilibrium

- The equilibrium sign (⇌) is used to show that both sides of the equation are present.
  - When all of the reactant particles remain as reactants and all of the products remain as products, it is known as **static equilibrium**
  - When there is a constant exchange from reactants to products (and visa versa), it is known as **dynamic equilibrium**

7.1 – Dynamic Equilibrium of Soda

- Fizzy drinks (such as coke) are made such by the dissolving of CO_2(g) in solution to CO_2(aq)
- In order for the soda to remain fizzy it must be kept under pressure, dynamic equilibrium exists
- Once the pressure is released, the equilibrium shifts back toward CO_2(g) due to a change in pressure
- This is a reversible reaction
  - $CO_2(g) + (aq) \rightleftharpoons CO_2(aq)$



7.1 – Chemical Equilibria

- A chemical equilibrium can only occur when a system is **closed**
- An example is the chemical test for Fe^{3+} ions in solution
- $Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons [Fe(SCN)]^{2+}(aq)$

Pale yellow colorless deep red

- By addition of various ions, the effect can be studied by monitoring the intensity of the red color of solution. The equilibrium may shift.
- This can be done with a SpectroVis or Colorimeter

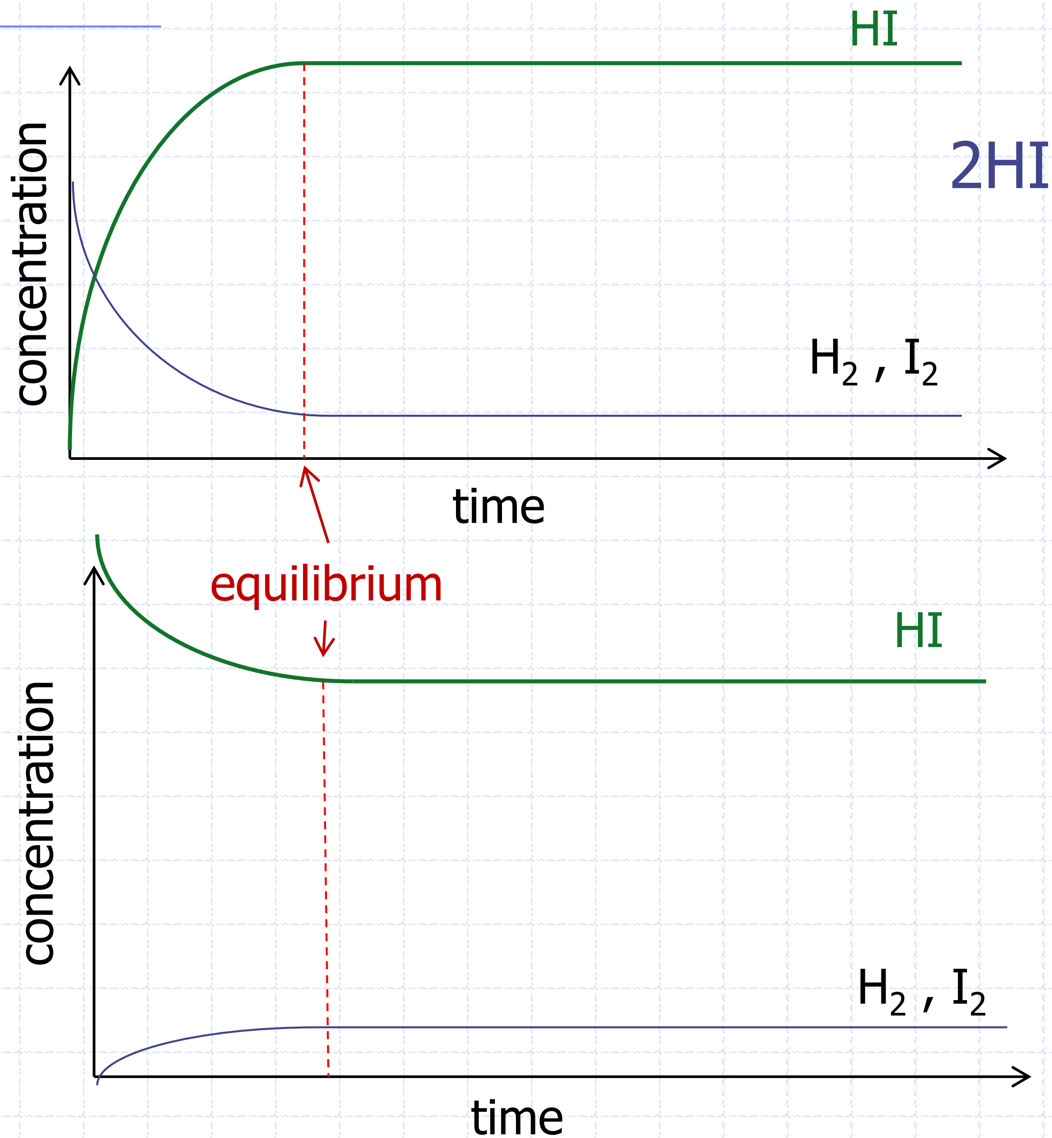
7.1 – Chemical Equilibria

- Another example is the dissociation between HI and it's elements I_2 and H_2
- $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

colorless colorless purple

- If the reaction is carried out there will first be a rapid increase in purple color then seems to stop
  - Actually, when [HI] is high the forward reaction is fast while the reverse is zero
  - Once [HI] is used up the forward reaction slows as the reverse reaction begins to pick up
    - When the rate of forward = reverse the system is in dynamic equilibrium

7.1 – Forward vs Reverse Reaction



$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

No matter which side of the equilibrium equation you start from, the same equilibrium is reached

7.1 – All reactions at Equilibrium

	Feature of equilibrium state	Explanation
1	Equilibrium is dynamic	Reaction has not stopped but both forward and reverse are in same rate
2	Equilibrium is achieved in a closed system	Prevents exchange of matter with surroundings, so equilibrium is achieved where both R and P can react and recombine
3	Concentrations of R and P remain constant at equilibrium	They are being produced and destroyed at an equal rate
4	At equilibrium there is no change in macroscopic properties	Refers to observable properties such as color and density. Do not change as they depend on [conc] of the components of the mixture
5	Equilibrium can be reached from either direction	The same equilibrium mixture will result under same conditions, no matter whether the reaction is started with all R, P, or mixture of both

7.1 – Concentrations in Equilibrium

- Even though [R] and [P] are constant in equilibrium, this **does not** imply that they are equal.
- In fact there will often be a much higher [conc] of one or the other depending on the reaction and the conditions (T, P, V, etc)
- [Reactants] $\rightleftharpoons$ [Products]

7.1 – Equilibrium Position

- Analogy – walk up a downward-moving escalator
  - Can you be at equilibrium in the middle, near the top, near the bottom?
  - As long as you are moving upward at the same speed the escalator is moving downward, you will be in equilibrium
  - This is known as the **equilibrium position**
  - **"Lie to the left"** favors reactants
  - **"Lie to the right"** favors products